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NO. 13082

USE OF THE

TACOM THERMAL IMAGING MODEL

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This report outlines the basic function and architecture of the TACOM Thermal Imaging Model. Typical use of the simulation model are given as well as examples of output imagery gererated from the model.

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LIST OF ILLUSTRATIONS

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1.0. INTRODUCTION

This report presents output imagery from TACOM's Thermal
Imaging Model (TTIM) developed by Timothy J. Rogne, Brian K.
Matise and Frederick G. Smith of Optimetrics, Inc. for the
U.S. Army Tank-Automotive Command (TACOM) under Contract
DAAE07-81-C-4053. TTIM is capable of processing measured or
modeled infrared scenes so as to account for FLIR sensor effects,
natural atmospheric effects, and battlefield environment effects.
This allows the operator to relate surface temperatures on the
vehicle to image grey levels and vice-versa. The importance of
the image simulation procedure is that the concept vehicle designer
for the first time will have simulated imagery of his vehicle
concept as seen through some threat sensor configuration. The
relative survivability criteria for various concept vehicle designs
can then be evaluated in a systematic manner.

2.0 TTIM ARCHITECTURE

A brief overview of TTIM is presented here. For detailed
information on the model refer to references 1 and 2. TTIM is a
menu driven program implemented on a VAX 11/750 computer system
interfaced to a Comtal image processing system. Attached to the
program are data libraries which provide the appropiate data for
various types of sensors, atmospheric conditions and obscuring
battlefield effects such as smoke or aerosols. Many of the various
sub-models which make up TTIM have been validated. Validation of
the model as a whole will be completed shortly.

TTIM can be divided into three submodels: the natural atmospheric
effects model, the battlefield effects model and the sensor model.
The natural atmospheric effects model is a version of LOWTRAN6
developed by the U.S. Air Force Geophysics Laboratory. LOWTRAN6
calculates atmospheric transmittance and radiance over .25 to
28.5 um [ref. 3]. The battlefield effects model is a version of
ACTMAD developed by Optimetrics for the U.S. Army Atmospheric Sciences
Laboratory (ASL). ACTMAD allows for multiple varieties of smoke
munitions and smoke sources positioned in any configuration [ref.4].
ACTMAD calculates a spatial map of the obscurant cloud attenuation and
path radiance. The sensor model basically consists of two parts: an
optical system model and a sensor subsystem model. The sensor
subsystem model utilizes the same transfer function forms as the
NV&EOL Static Performance Model for Thermal Viewing Systems [ref. 5].

TTIM also has the ability to perform the inverse of the process
described above. This allows the user to inverse process recorded
field data to remove sensor and atmospheric effects and obtain an
apparent temperature map of the scene. This unique capability can
assist the vehicle designer in reducing the signature of a fielded
vehicle.

3.0 TTIM APPLICATIONS

TTIM can aid in many areas of image processing and scene analysis.
Immediate plans are to integrate TTIM into on-going vehicle perceptability
research programs conducted at TACOM [ref. 6,7,8]. This work is concerned
with imp.oving vehicle survivability by identifying and reducing vehicle
signature cue features which contribute to target detection. TTIM can
provide the vehicle designer with an extremely attractive, cost effective
tool for evaluating concept vehicle survivability. Applications for TTIM
also include search process modeling studies of human observers to
establish and confirm detection and recognition criteria. In
addition, TTIM could assist in thermal sensor design and evaluation
and also in evaluating smoke and weather obscurant effectiveness.
TTIM can also assist in establishing sensor platform stabilization
requirements.

4.0 TTIM OUTPUT IMAGERY EXAMPLES

The following pages contain examples of imagery generated via
the use of TTIM. Each figure is labeled with target range, weather
conditions, type of aerosol present and sensor type. Three different
sensors are used in the examples. To avoid classification of this
document the names of the sensors have been withheld and are referred
to as SENSOR A, SENSOR B, AND SENSOR C. SENSOR A has a serial 1x14
scanning detector array and SENSOR B has a serial 2x14 scanning detector
array. Both SENSOR A and SENSOR B have a f-number of 2.0 and a
detector area of 4.50 x E-06 cm**2. SENSOR C has a parallel 180x1
scanning detector array, a f-number of 2.53 and a detector area of
2.58 x E-05 cm**2.

The tank scene in figure 1 illustrates the effect rain has on
SENSOR C. Presently the model outputs the average effects rain has
on a thermal scene. Modeled weather conditions are also assumed to
be spatially symmetric. Phase II of the model will address both of
these issues.

The model has zoomed on the tank in figures 2 thru 5 to show the
resolution loss suffered when viewing distant targets. Later figures
do not zoom on the data in this manner and therefore a distant tank
appears smaller than a close tank through the same field of view lens.
Figure 2 illustrates a best case scenario using SENSOR A when viewing
a tank at the ranges shown. Note in this figure that at a 5 km target
range even in a clear atmosphere the target is barely perceptable using
this sensor. Figure 3 contains the same input image as for the 1 km
case except the atmosphere has several different densities of fog.

Figures 4 and 5 illustrates a performance comparison for ideal
and fog atmospheres between three sensors. The figures show that at
1 km target range in a clear or thin fog atmosphere there are only
slight differences between each sensor's output. Close examination

shows that SENSOR B is slightly better than SENSOR A,most likely due to the square root of two improvement in the sensor's signal to noise ratio. Similar the output using SENSOR C is of better quality than that of SENSOR B's. The differences between each sensor's output is enhanced when viewing in less favorable conditions. At 3 km target range in figures 4 and 5 the tank is much more recognizable using SENSOR C and in the ideal atmosphere case it is possibly even identifiable.

Figures 6 thru 9 represent a case study using the same three sensors and an ideal sensor viewing a tank at one and three kilometers through a clear and rainy atmosphere. In this imagery the data is scaled properly so that the tank at 1 km appears three times as large as the tank at 3 km. The same performance trends observed in figures 4 and 5 between the three sensors can be seen in figures 6 thru 9. Note that although SENSOR C appears to be a very good sensor there is a significant difference between SENSOR C's imagery in figure 9 and the ideal sensor imagery in figure 6, particular at 3 km target range.

The performance of each sensor in the battlefield atmospheric effects module was also analyzed. The L8A1 and XM76 smokes grenades were set off at various distances and spacings between the sensor and the target. Final results and hard copies of these tests however were not available at the time of publication.

The model is also ideal for establishing sensor stabilization parameters. Figure 10 contains a tank at one kilometer when viewed with a sensor mounted on a non-stable platform. The imagery illustrates the degrading effect vibration at 0, 200, 400, and 600 u-radians rms can have on the sensor's performance. Even at 1 km target range as in figure 10, the vibration causes the vehicle's road wheels and smaller components to become indistinguishable. At longer target ranges, the degrading effect of sensor vibration will be increased and the vehicle's detected signature will tend to blend in more and more with the background.
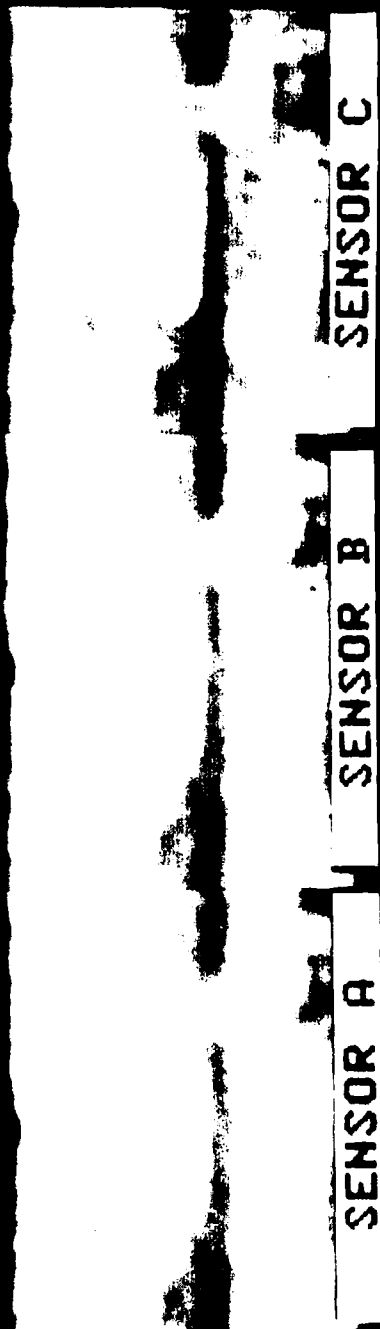
RANGE. 5KM

RANGE. 3KM

2KM VISIBILITY, 1KM VISIBILITY
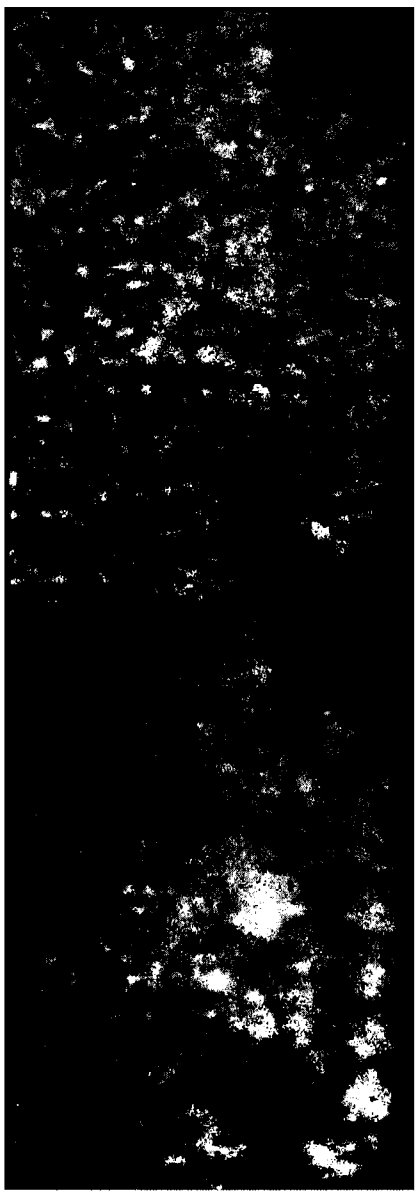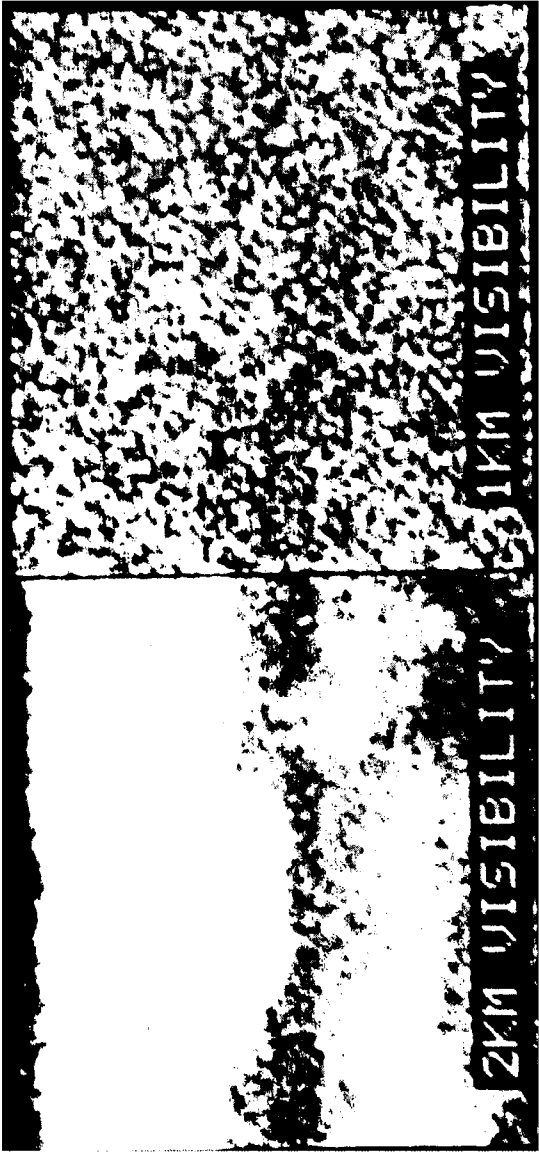
SENSOR COMPARISON
IDEAL ATMOSPHERE

RANGE = 1KM

SENSOR A   SENSOR B   SENSOR C

RANGE = 3KM

SENSOR A   SENSOR B   SENSOR C

FIGURE 4

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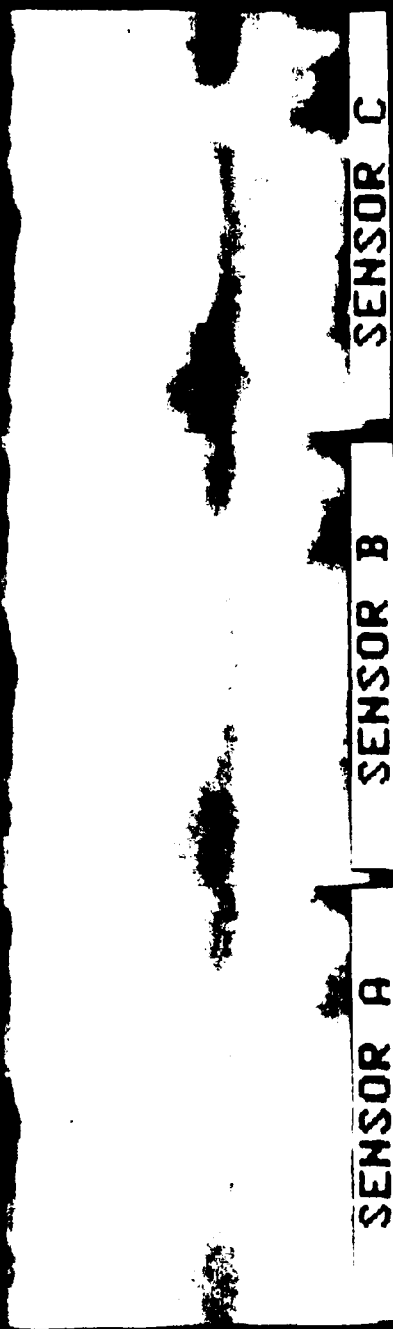
SENSOR COMPARISON
ADVECTION FOG
5KM VISIBILITY

RANGE = 1KM
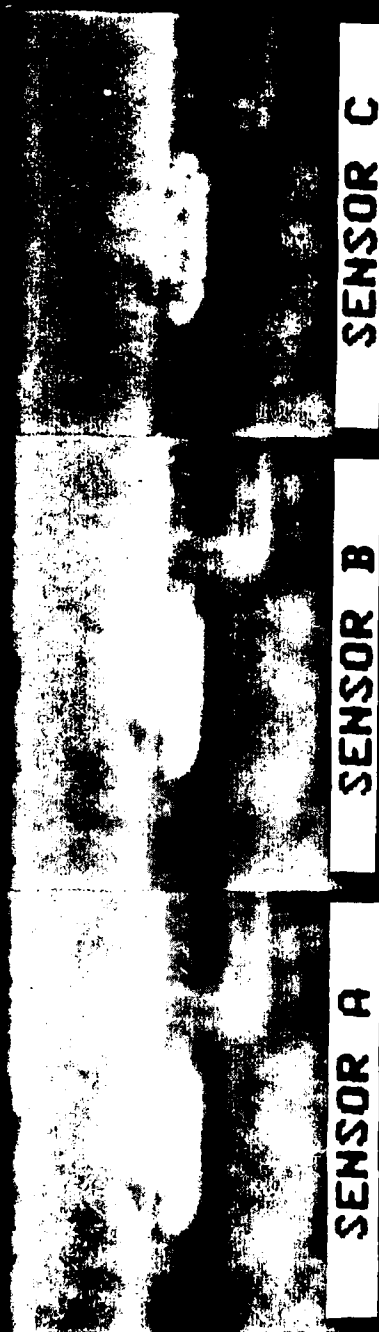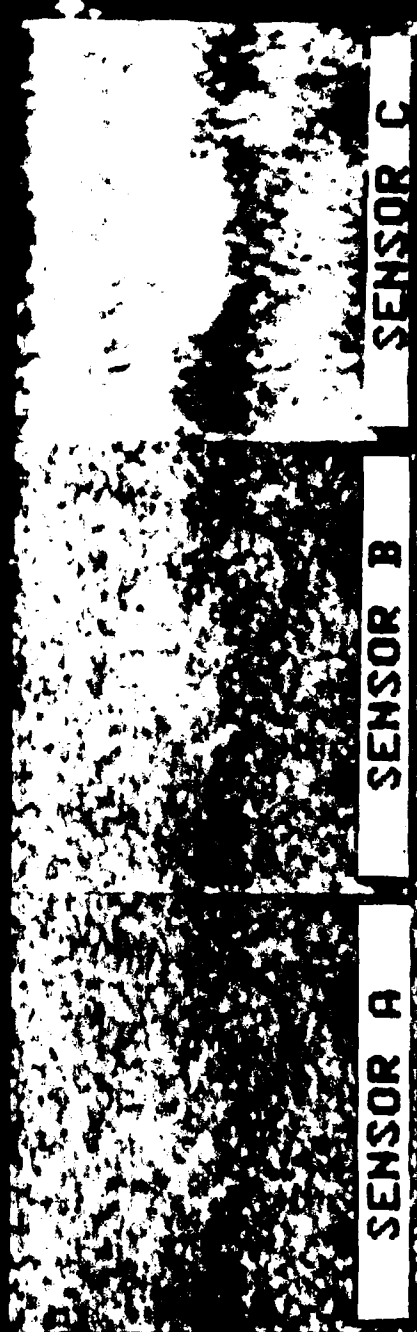
SENSOR A SENSOR B SENSOR C

RANGE = 3KM

SENSOR A SENSOR B SENSOR C

FIGURE 5

14

IDEAL HEMISPHERE

FIGURE 6

15

SENSOR A

FIGURE 7

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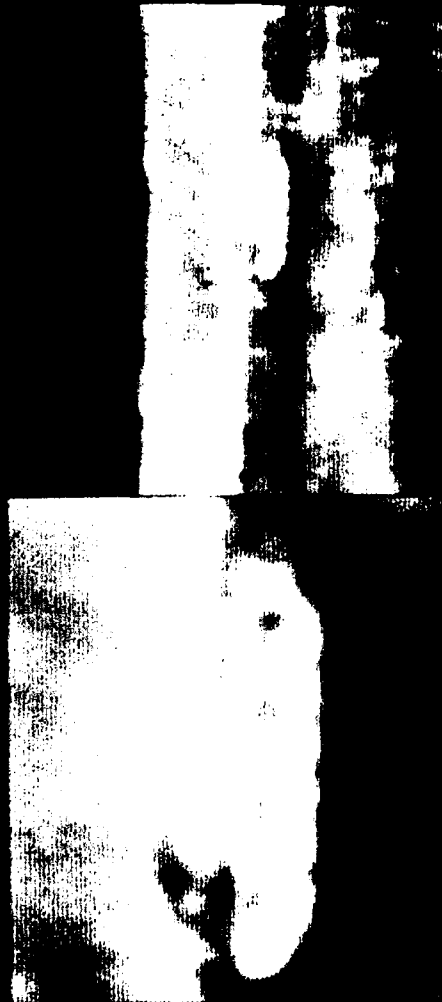
SENSOR B

RANGE: 1 KM

RANGE: 1 KM

RAIN = 3.12 MM/HR
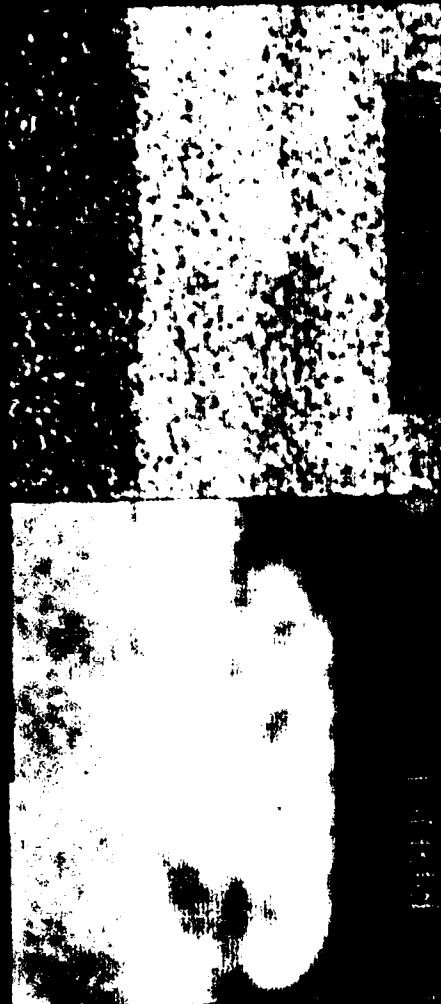
FIGURE 8

SENSOR C

FIGURE 9

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SENSOR VIBRATION SIMULATION

PARAMETERS: IMAGE RESOLUTION = 256 X 218
            FIELD OF VIEW   = 2 DEGREES
            SPOT SIZE   = 0.15 M
            RANGE   = 1000 M

FIGURE 10

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